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ANODIC ETCHING - A METHOD OF DETECTING
GRINDING BURNS ON CHROMIUM PLATED STEEL PARTS

E. A. Lauchner, et al

Northrop Corporation
Hawthorne, California

7 February 1975

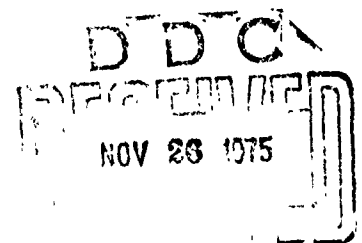
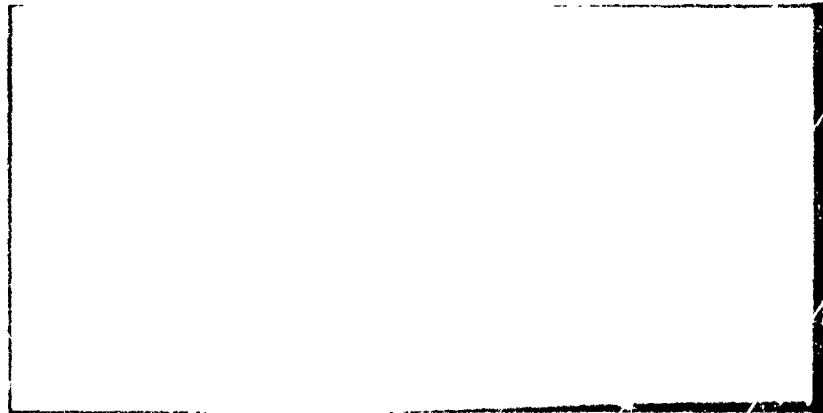
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ANODIC ETCHING - A METHOD OF DETECTING GRINDING BURNS ON CHROMIUM PLATED STEEL PARTS

7 February 1975

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ABSTRACT

Anodic etching, a method for detecting abusive grinding damage on chromium plated steel parts, is evaluated.

Anodic etching procedure for inspecting chromium plated steel pins was studied and the mechanism of the anodic etch burn indication is discussed. In addition, the results of magnetic particle and penetrant inspection of the pins is presented.

The results indicate that abusive grinding of chromium plate can cause cracks or burns in the plate or base metal that are not detected by conventional inspection techniques. Anodic etching is a useful technique for determining if chromium plate has been burned by abusive grinding. If the plate is burned, further investigation is required to determine whether the base metal is burned or cracked.

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1. INTRODUCTION

The aircraft industry has been plagued with the problem of burning high strength steel parts by abusive machining or grinding. Burns on steel parts degrade the fatigue properties of the base material, and many service failures have been attributed to this type of burning. Nital etching has been used as a method to detect burns on steel surfaces. However, abusive grinding of chromium plated steel parts can also cause burns beneath the plate on the steel surface (Ref. 1 and 2).

Abusive grinding of chromium plate results from an excessive rate of metal removal or inadequate cooling of the work-piece during the grinding operation. Friction generated between the grinding wheel and the chromium plate causes heat to build up locally to very high levels. Since chromium and steel have low thermal conductivity, the heat is not conducted away adequately. The heat builds up in the plate and the steel, causing retempering or rehardening burns in the steel.

The industry has tried to exercise close control over grinding of chromium plate, and therefore to minimize the tendency to produce thermal damage. Precise manufacturing and process controls have been imposed to control the feeds, speeds and coolants used when grinding chromium plate. These controls are necessary. However, the controls are not entirely adequate as damage can still occur due to improper grinding. There

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1. INTRODUCTION (Continued)

has been no adequate nondestructive inspection technique available to determine if burns exist on the surface of the steel part beneath the chromium plate.

Current techniques for inspection, such as the magnetic particle method, are only effective in detecting large grinding checks (indications of base metal cracks evident through the chromium plate). Chromium plate in thicknesses above 0.0007 inch reduces the crack detection capability of magnetic particle inspection (Ref. 3). The loss of detection is more pronounced above 0.003 inch of plate. Regardless of plating thickness, small fine cracks beneath the chromium plate are usually not detected. It is important to repeat that magnetic particle inspection will not detect damage that has not caused cracks beneath the chromium plate.

A new process for detecting abusive grinding damage on chromium plate has recently been developed (Ref. 4). The process, called "Anodic Etching", utilizes an alkaline solution and a high current density to etch (strip) the smeared chromium from the plated surface. Initial evaluations have shown anodic etching to be a practical way of detecting thermal damage on chromium plate caused by abusive grinding. If the plate is damaged, further investigation of the base metal is indicated.

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2. OBJECTIVE

The object of this program was to determine if the anodic etching technique will detect burns on steel through the chromium plate. The fundamental mechanism of the technique was evaluated, and the processing requirements necessary to implement the inspection procedure into production were determined. Also, the capabilities of magnetic particle and penetrant inspection were evaluated as aids in inspecting chromium plated steel parts for cracks.

3. CONCLUSIONS

1. The present practice of plating parts oversize and grinding to final dimensions is unsatisfactory. Abusive grinding can cause cracks and burns in the base metal that are usually not detected by conventional inspection procedures.
2. Anodic etching of ground chromium plated steel parts is a useful technique for determining whether or not the chromium plate has been damaged. If the plate is damaged, further investigation is required to determine whether the base metal is burned or cracked.
3. Fluorescent magnetic particle inspection is more sensitive than the black oxide method for detecting grinding checks on chromium plated parts.

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3. CONCLUSIONS (Continued)

4. High intensity magnetic particle inspection will not detect base metal cracks through chromium plate any better than normal magnetic particle inspection.

4. RECOMMENDATIONS

There are two alternatives to the present procedure of finish grinding parts chromium plated oversize to reduce the danger of grinding burn damage:

1. Anodic etch inspection should be implemented on parts chromium plated and ground, or
2. Parts should be chromium plated to size to eliminate the grinding.

5. PROCEDURE

5.1 INITIAL INSPECTION

Four steel pins were selected for evaluation that were scrapped due to evidence of grinding checks on the chromium plate. These pins were made from 300M bar and were heat treated to 280 to 300 ksi ultimate strength. They were chromium plated on the 1.75 inch diameter to a thickness of $0.003 \text{ inch} \pm 0.0001$. A typical pin is shown in Figure 1. Each of the pins were identified as 1,2,3,or 4 by vibratory etching

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5. PROCEDURE (Continued)

on the head end.

The pins were vapor degreased and cleaned. They were fluorescent magnetic particle inspected using both head and coil techniques at 1800 and 6000 amperes current respectively. The pins were demagnetized and solvent cleaned, after inspection.

Pins 1, 2, and 3 were magnetic particle inspected using both fluorescent and black oxide particles. Photographs were taken of the indications produced. High intensity magnetic currents of 2800, 4000, and 5000 amperes were also evaluated.

Penetrant inspection was attempted on all four pins. However, no indications of cracks could be detected through the chromium plate.

Residual stress measurements on pin number four were taken on four different areas on the chromium plate using the Rigaku-Strain Flex machine.

5.2 ANODIC ETCHING

All four pins were anodic etched. Two different bath compositions were evaluated. One contained sodium hydroxide and potassium pyrophosphate; the other contained sodium carbonate and sodium hydroxide. Preliminary tests showed that both solutions etched the chromium plate equally well. However, because of difficulty in mixing the pyrophosphate, the higher solution content of chemicals required, and the higher cost, all

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7 February 19755. PROCEDURE (Continued)

subsequent tests are performed using the carbonate and hydroxide solution.

Various times for etching such as 45, 90, 180, 450 seconds were evaluated initially. However, 45 seconds appeared to give an adequate etch, and longer times tended to remove excessive chromium plate. Subsequent etching on the four pins was performed using a 45 second etch time.

The anodic etching solution control parameters are as follows:

Sodium Carbonate	-	9 to 20 ounces per gallon
Sodium Hydroxide	-	5 to 10 ounces per gallon
Current density	-	2.5 to 3.5 amperes per square inch
Bath temperature	-	65 to 110 F
Etching time	-	45 to 60 seconds
Alkalinity	-	pH 11-12, 20-30° Baume

The procedure for anodic etching consisted of the following:

1. Vapor degrease or solvent wipe pins.
2. Attach electrical contacts made of braided copper wire.
3. Mask all areas not requiring etching with peelable maskant or tape.
4. Hand clean chromium plated area using cheesecloth and 1 to 5 micron aluminum oxide abrasive cleaner.
5. Water rinse. Check for water breaks.

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5. PROCEDURE (Continued)

6. Immerse in alkaline cleaner at 130 to 180 F for 3 minutes.
7. Hot water rinse. Inspect pins for a water-break-free surface.
8. Immerse pins in anodic etching solution.
9. Electrolyze pins for 45 to 60 seconds at a current density of 2.5 to 3.5 amperes per square inch of exposed chromium plate using the pins as an anode.
10. Remove part from etchant and remove masking materials.
11. Rinse in hot water. Dry thoroughly.
12. Inspect pins for adequate etch and for evidence of grinding burns.

5.3 INSPECTION

The diameter of pin number one was measured after various etching times before and after etching. In addition the surface finish of the pin was evaluated both before and after etching.

Pins 1, 2, and 3 were inspected after anodic etching by the magnetic particle and penetrant methods. Photographs were taken. Three pins were penetrant inspected using WP-167 fluorescent penetrant. The pins were soaked for 5 minutes, washed, examined under an ultraviolet light, dried, lightly coated with nonaqueous developer and examined again. A special technique was also used of washing under the ultraviolet light until all indication of penetrant was removed, wiped dry, and then

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5. PROCEDURE (Continued)

examined.

Photographs were also taken of the indications revealed by anodic etching.

Pin number four was stripped of chromium plate after etching using an alkaline stripper. The pin was then magnetic particle inspected. In addition, the pin was nital etch inspected to reveal burns on the steel surface. Photographs were taken.

Residual stress measurements were taken on pin number four, after stripping of chromium, in the same areas measured before, except, the Fastress machine was used.

6. RESULTS AND DISCUSSION

6.1 INITIAL INSPECTION

Crack indications revealed by fluorescent and black oxide magnetic particle inspection are shown in Figure 2. There is a significant difference in crack indications revealed by the black oxide versus fluorescent techniques. The indications shown by the fluorescent method are more distinct and easier to evaluate due to the inherent color contrast.

The high intensity magnetic current inspection techniques evaluated were not successful in detecting any additional cracks.

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6. RESULTS AND DISCUSSION (Continued)

The high intensity currents caused excessive background (non-relevant) indications. Therefore, no further gain in true indications could be certain.

Penetrant inspection on the chromium plated pins was also investigated. Excessive penetrant bleedout caused by inherent chromium plate porosity, and grinding smears on the plate caused unsatisfactory results for this inspection technique.

6.2 ANODIC ETCHING

The appearance of pin number four after anodic etching is shown in Figure 3. The removal of the smeared chromium plate, caused by the grinding of the pin, leaves a dull matte finish on the chromium plate. If the chromium plate is damaged, it is normally evident immediately after anodic etching. If a burn does exist on the plate, the burn can be seen due to differences in reflectivity. This examination is best performed at 25 to 50X magnification with a stereomicroscope. As seen in Figure 3, a spiral mark (sometimes called a burn) is evident near the thread end of the pin.

The spiral mark on the chromium plate revealed by anodic etching is not really a burn. Instead, a gross cracking of the chromium plate is being revealed in the so-called burned area as compared to the unburned area. This effect is shown in Figures 4 and 5. The gross cracking (mud cracking) in the damaged areas reflects light differently than the normal chromium plate (haze).

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6. RESULTS AND DISCUSSION (Continued)

The haze is normal for all chromium plating and represents the normal crack pattern of this inherently "cracked" plate. The mud cracks are results of thermal heating and cooling of the plate due to overheating from improper grinding. The cooling of the overheated plate causes large cracks to form through the normal plate. These mud cracks are what is seen after anodic etching and indicate damage.

Figure 6 shows the nature of the chromium cracks when examined by the SEM. Figure 7 shows photomicrographs of cross sections through the chromium plate. The inherent discontinuous cracks (haze) are evident in the normal plate. Mud cracks are shown to be large cracks penetrating the plating; many of the cracks penetrate to the base metal.

Mud cracks are the only evidence of thermal damage to the chromium plate. The subsurface steel may or may not be overheated and damaged. Subsequent stripping of the chromium plate and nital etching the bare steel is the only way to determine if a part is overheated. However, if the chromium plate did reveal mud cracks, it is very important to investigate further. If there is no plate damage, the part is not overheated. Also, it is important to realize that the large mud cracks may act as stress risers for subsequent in service fatigue initiation.

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6. RESULTS AND DISCUSSION (Continued)

The anodic etching procedure is relatively simple to perform. It can easily be performed by any plating shop that desires to mix the required chemicals. A preliminary specification covering the basic aspects of the anodic etching procedure and required controls is included in the appendix.

The amount of chromium plate removed by anodic etching is shown in Table 1. The etch rate for the process is about 0.0003 to 0.0004 inch per minute. Since the normal time for etching is 45 seconds, about 0.0003 inch of chromium is removed from the diameter of a pin during normal inspection.

The surface finish of the chromium plate before and after etching is shown in Table 2. The RHR rating of a nonburned anodic etched part will increase about 50 percent. This finish may require a slight honing after inspection to meet any special finish requirements. If a part exhibits mud cracks, the finish may increase by a factor of two. However, the part should be stripped of all chromium plate anyway, so the increase should not present a problem.

6.3 INSPECTION

Anodic etched pins 1, 2, and 3 are shown in Figure 8 after fluorescent magnetic particle and penetrant inspection. The crack indications originally shown in Figure 2 are evident. Magnetic particle inspection sensitivity has not increased by

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6. RESULTS AND DISCUSSION (Continued)

removal of chromium during anodic etching. Removal of smeared metal has helped penetrant inspection. Prior to etching, crack indications were not evident by penetrant inspection. However, penetrant inspection of etched chromium plate is not recommended because of problems in removing penetrant and the extreme shallowness of the cracks in the plate.

Pin number four was magnetic particle inspected after etching and stripping of the plate. Photographs are shown in Figure 9. Cracks were revealed after stripping of plate that were not evident initially.

This finding is very important. It is therefore obvious that small cracks can be masked by chromium plate that magnetic particle inspection cannot detect. Only anodic etching can give an indication that such cracks may exist. This is of course by indirect means - grinding damage revealed on the chromium plate requires further investigation and stripping of the plate, which will permit detection of the cracks.

It is of interest to consider how many steel parts have been plated, ground, and damaged that may have undetected cracks beneath the plate. Anodic etching, for the first time, offers a technique to determine if such cracks do exist.

Pin number four was nital etched after stripping. The retempering and rehardening burns detected are shown in

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6. RESULTS AND DISCUSSION (Continued)

Figure 10. The burns revealed by nital etching correlate very well with the burns indicated by anodic etching.

The residual stress results are listed in Table 3 for pin number four. A limited number of measurements on other pins tended to substantiate these results. The residual stresses on ground chromium plate are high tensile stresses as expected. After stripping of the plate, the residual stresses on the burned steel are neutral to tensile. The stresses are high in compression in the unburned part, as expected.

The pins were originally shot peened so they should have high compressive stresses. The overheating in the burned area has apparently reduced the benefits of the shot peening.

It was originally thought that residual tensile stress measurements on the chromium plate might indicate that the substrate was burned. These limited results tend to negate that possibility.

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7. REFERENCES

1. E. A. Lauchner, "Analysis of Grinding Burns on Aircraft Parts," Northrop Corp., Aircraft Division, Unpublished Report, 1974.
2. E. A. Lauchner, "Analysis of Grinding Burns on Landing Gear Pistons," Northrop Corp., Aircraft Division, Unpublished Report, 1974.
3. O. G. Molina, "Effect of Electroplating on Magnetic Particle Inspection Crack Detectability," NDT 4-4-1, Rockwell International, 1974.
4. R. W. Messler and R. R. Maller, "A New Inspection Process for Detecting Abusive Grinding Damage in Hard Chromium Plated Parts," Paper Presented 1974 Airlines Plating Forum, Grumman Aerospace Corp., 1974.

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TABLE 1. MATERIAL REMOVED BY ANODIC ETCHING

Time, Seconds	Diameter After Etching, inches (1)	Amount Removed From Diameter, inch
45	1.8011	0.0003
90	1.8008	0.0006
180	1.8003	0.0011
450	1.7988	0.0026

NOTE: 1. Original diameter was 1.8014 inches, current density 3 amperes per square inch, voltage 12, solution temperature 88 to 92 F.

TABLE 2. SURFACE FINISH OF CHROMIUM PLATE ANODIC ETCHED

Chromium Surface Measured	Surface Finish, RHR		
	Cutoff, inch		
	0.003	0.010	0.030
As Plated and Ground	9	10	12
Anodic Etched (no burns)	16	18	19
Anodic Etched (mud cracked)	23	27	30

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TABLE 3. RESIDUAL STRESS MEASUREMENTS

Process	Area			
	A	B	C	D
	Residual Stress, ksi			
As Chromium Plated and Ground	+55	+27	+82	+69
After Stripping of Plate - Bare Steel	+13	-11	-120	-116

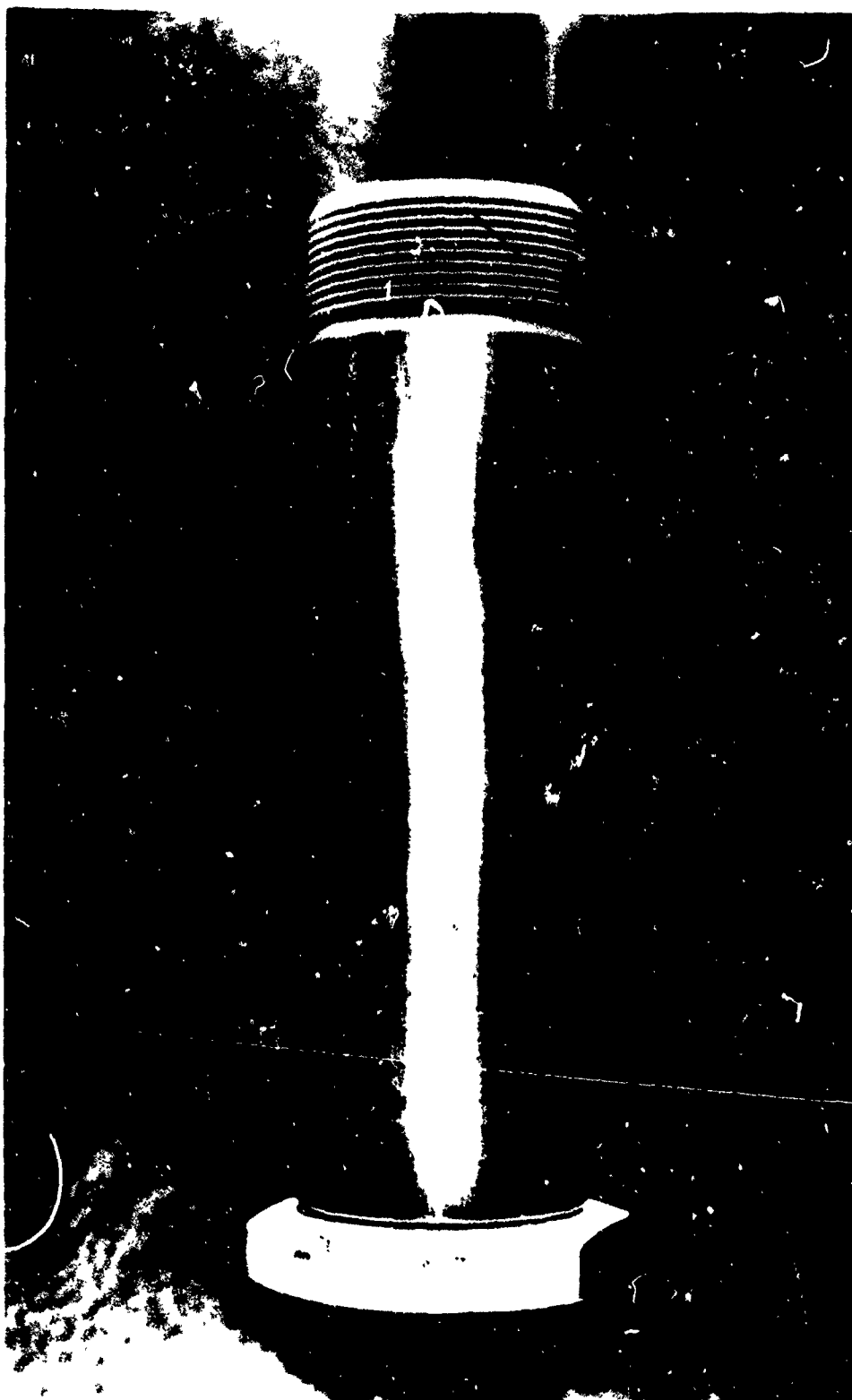
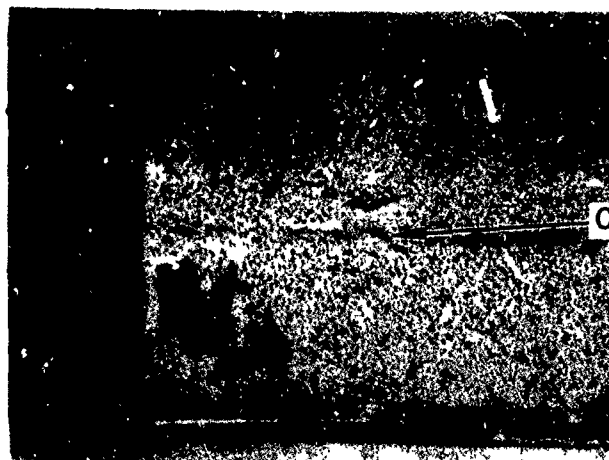


FIGURE 1. CHROMIUM PLATED MAIN WING ATTACH PIN
USED FOR TEST PROGRAM



CRACKS



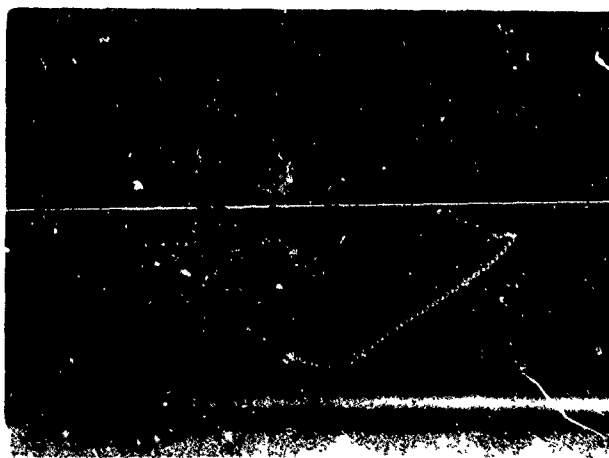
PIN 1



CRACKS



PIN 2



BLACK OXIDE

PIN 3
1-1/4X

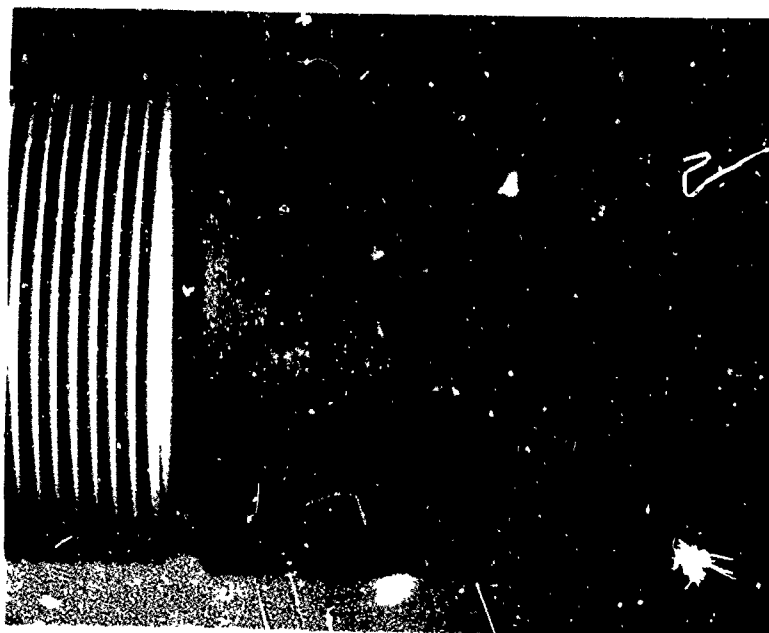


FLUORESCENT

FIGURE 2. INDICATIONS REVEALED BY MAGNETIC PARTICLE INSPECTION
ON THREE DIFFERENT CHROMIUM PLATED PINS

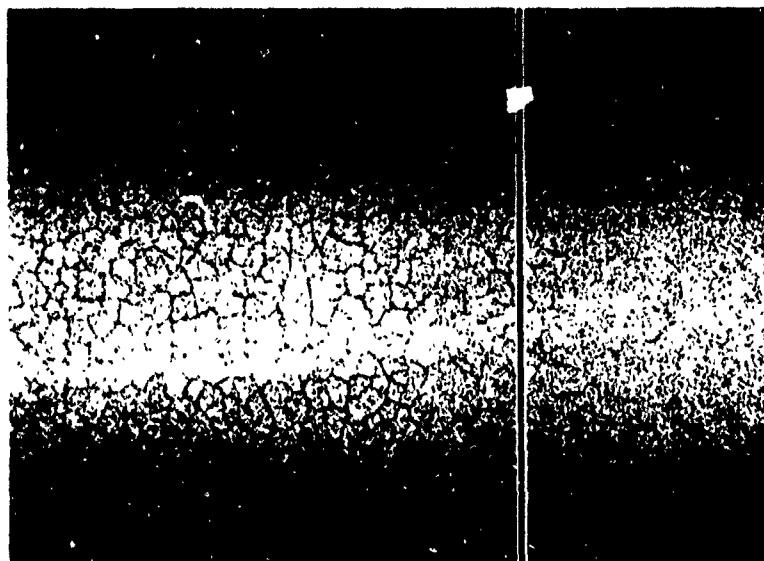


3/4X



2X

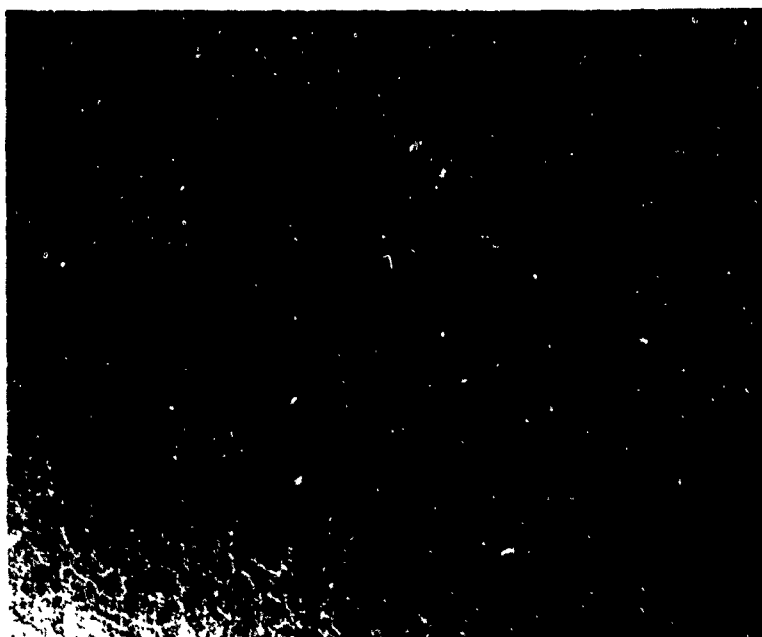
FIGURE 3. GRINDING DAMAGE ON CHROMIUM PLATE
REVEALED BY ANODIC ETCHING



MUD CRACKED CHROME

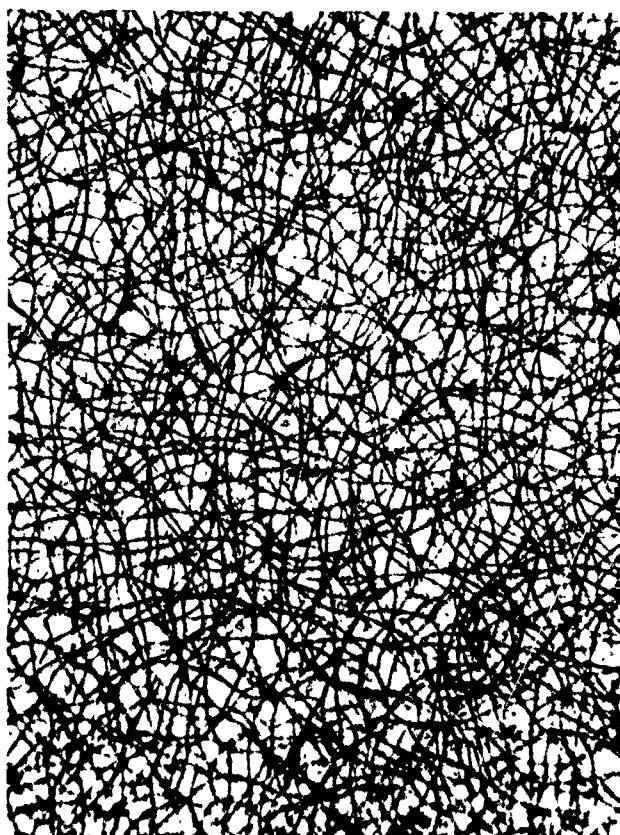
GOOD CHROME

12X



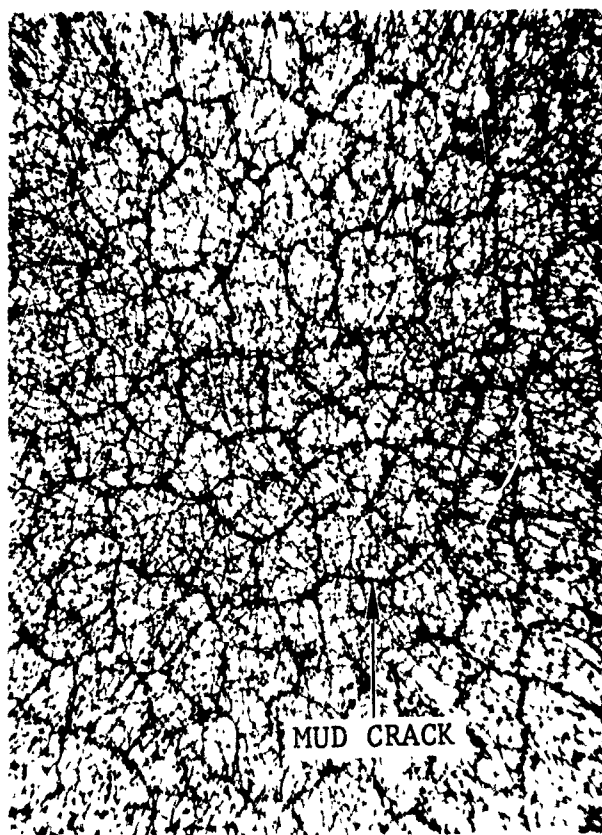
15X

FIGURE 4. MUD CRACK PATTERN IN DAMAGED AREA OF CHROMIUM
PLATE REVEALED BY ANODIC ETCHING



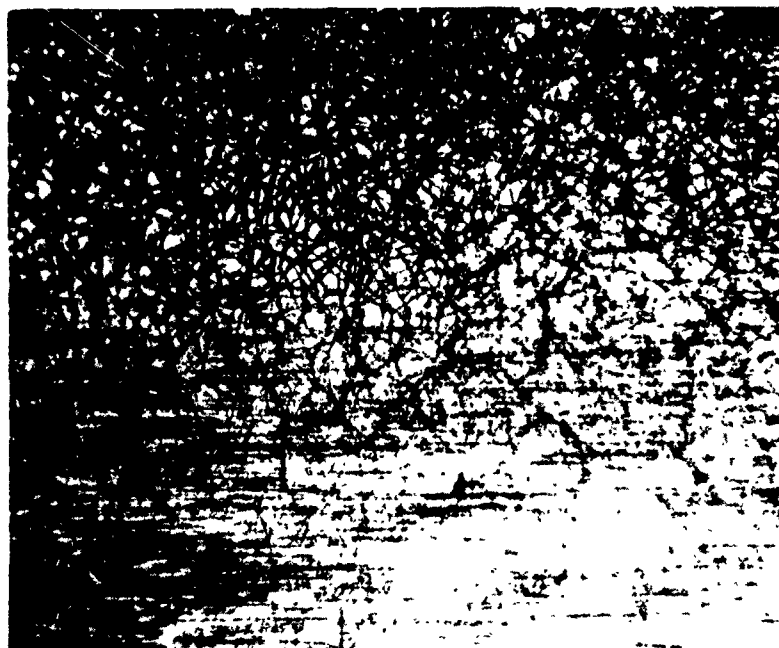
HAZE EVIDENT ON NORMAL PLATE

50X



MUD CRACKS EVIDENT ON DAMAGED PLATE

50X



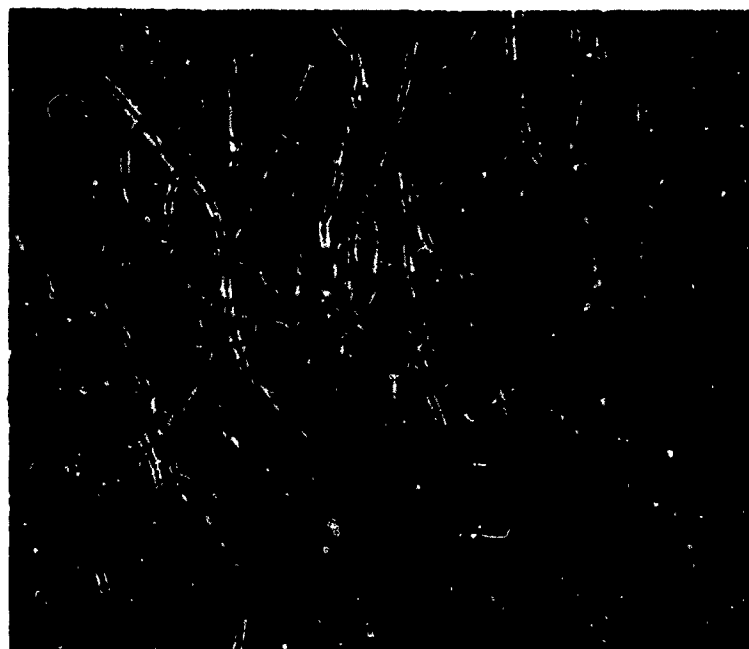
ETCHED

GROUND

TRANSITION BETWEEN ETCHED AND GROUND PLATE

50X

FIGURE 5. SURFACE OF NORMAL CHROMIUM PLATE AFTER ANODIC ETCHING



200X

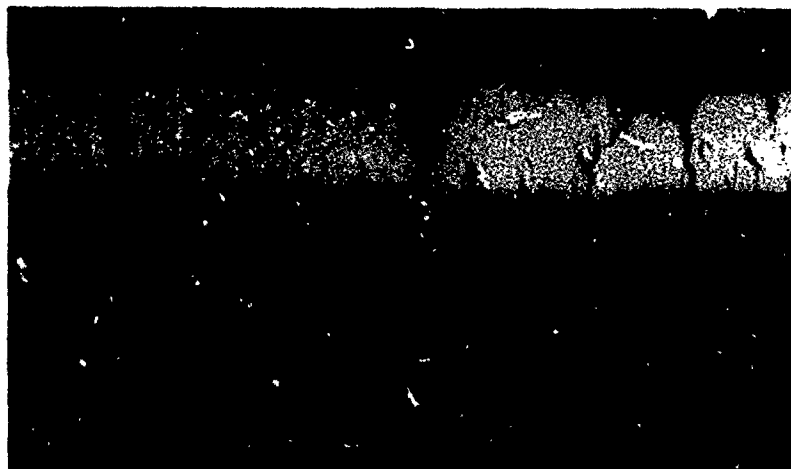
INHERENT CRACKS IN NORMAL CHROMIUM PLATE



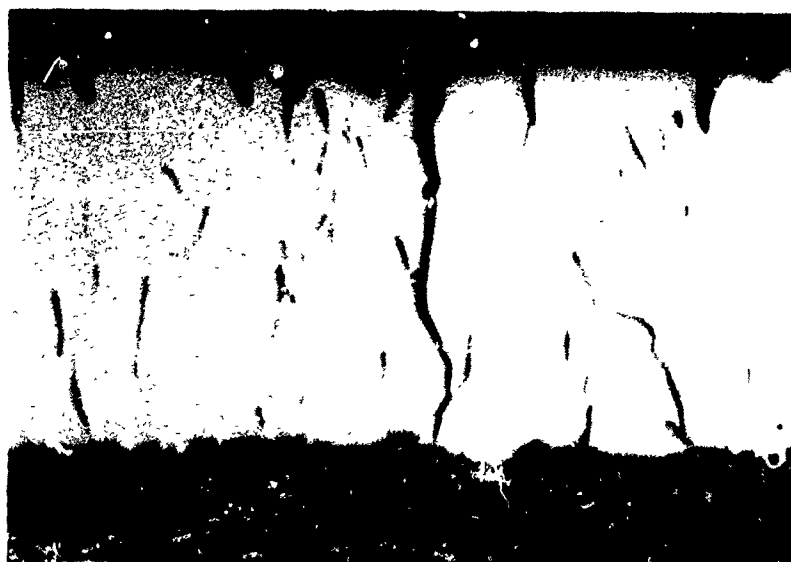
200X

MUD CRACKS IN DAMAGED CHROMIUM PLATE

FIGURE 6. SEM PHOTOGRAPHS OF CHROMIUM PLATED SURFACE
AFTER ANODIC ETCHING

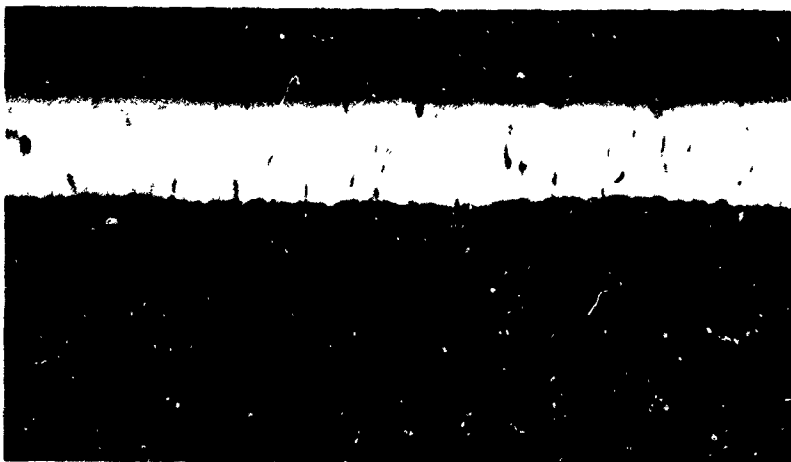


200X



500X

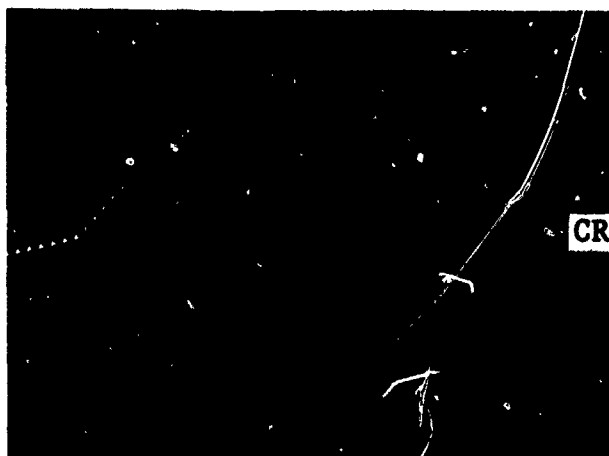
MUD CRACKS THROUGH BURNED CHROME



200X

INHERENT CRACKS IN NORMAL CHROME PLATE

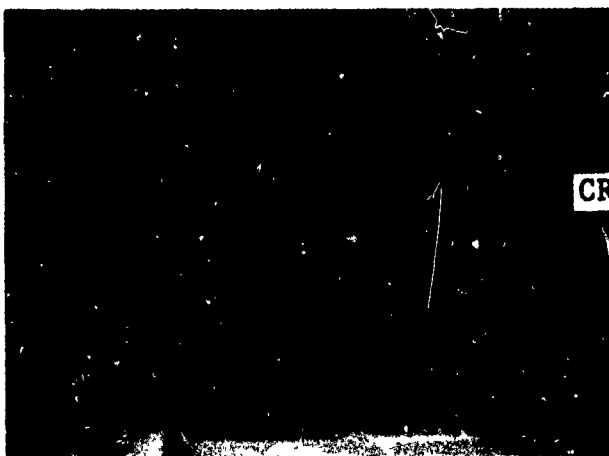
FIGURE 7. PHOTOMICROGRAPHS OF CHROMIUM PLATED STEEL
AFTER ANODIC ETCHING



CRACKS



**PIN 1 FLUORESCENT PENETRANT
IN THREADS**



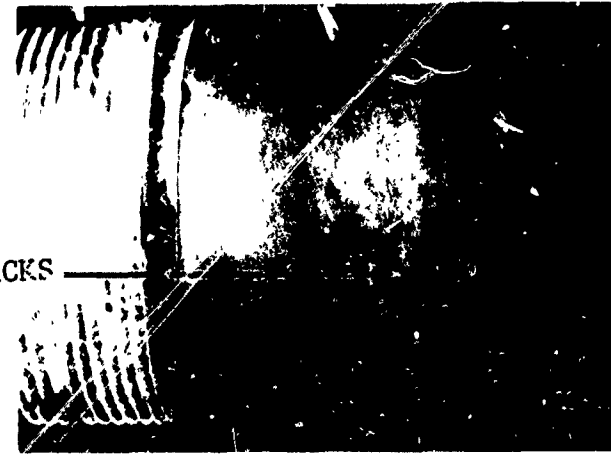
CRACKS



PIN 2



CRACKS

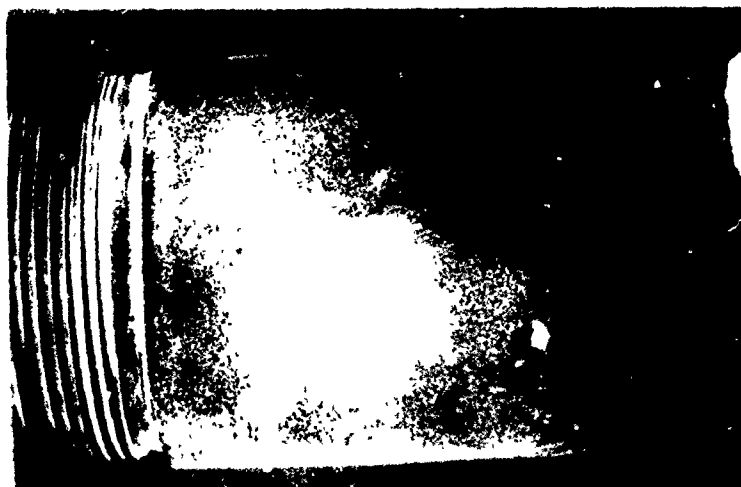


**FLUORESCENT MAGNETIC
PARTICLE INSPECTION**

**PIN 3
1-1/4X**

**FLUORESCENT PENETRANT
INSPECTION**

**FIGURE 8. INDICATIONS REVEALED AFTER ANODIC ETCHING
OF THREE DIFFERENT CHROMIUM PLATED PINS**



CHROMIUM PLATED

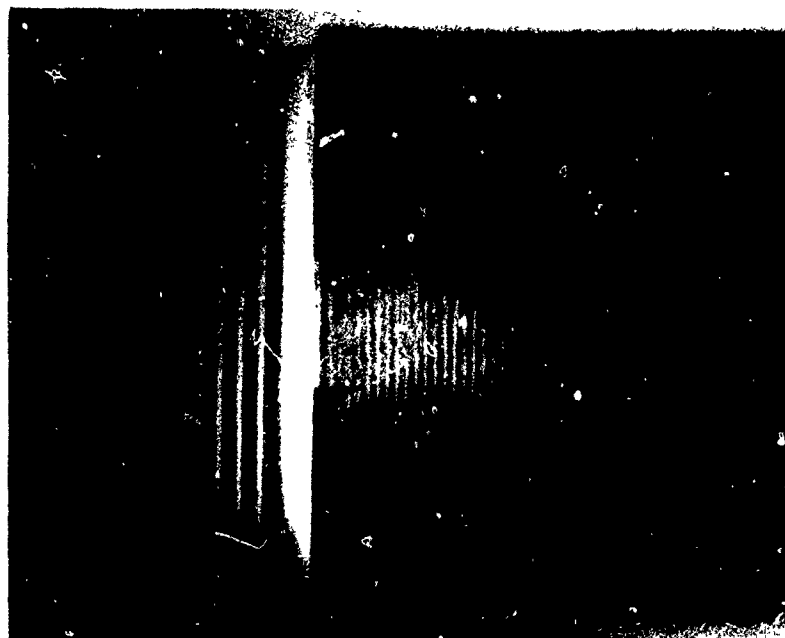


HIGH INTENSITY INSPECTION AFTER ANODIC ETCHING

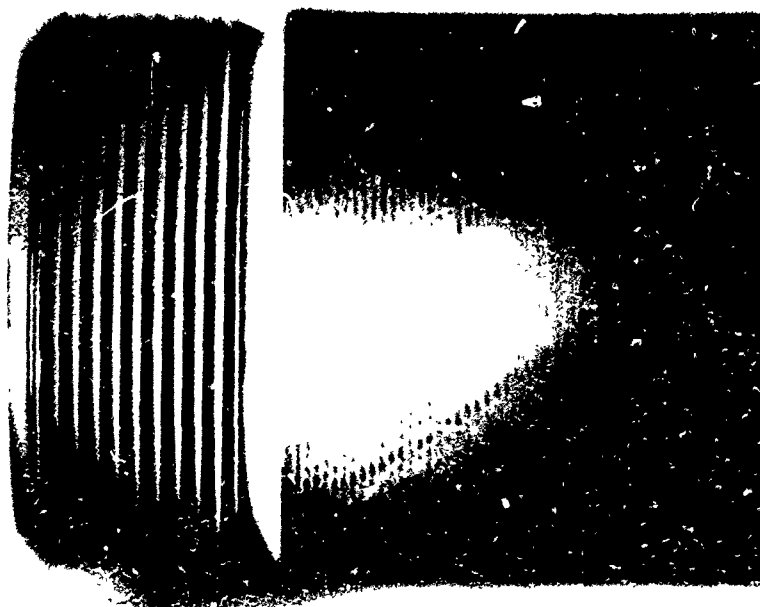


CRACKS REVEALED AFTER STRIPPING CHROMIUM PLATE

FIGURE 9. MAGNETIC PARTICLE INSPECTION ON
PIN AFTER VARIOUS OPERATIONS



ONE SIDE



OTHER SIDE

1-1/2X

FIGURE 10. BURNS REVEALED BY NITAL ETCHING OF BARE STEEL.
AFTER STRIPPING CHROMIUM PLATE

RESPONSIBLE ENGINEER <i>Ed Louchner</i>	NORTHROP Northrop Corporation Aircraft Division PROCESS SPECIFICATION	IT-70 DATE <u>1 July 1974</u> RELEASE EO <u>D86168</u> CODE IDENT NO <u>76823</u>
AIRCRAFT DIVISION		
SPECIFICATION CONTROL		
QUALITY CONTROL ENGINEER		
PROJECT OFFICE		

TITLE: ANODIC ETCH INSPECTION OF CHROMIUM PLATED STEEL PARTS

1. SCOPE

- 1.1 This specification establishes the requirements for anodic etch inspection of ground chromium plated high strength steel parts to detect damage caused by grinding the chromium plate.
- 1.2 Safety provision for handling and use of hazardous materials listed herein are specified in the Aircraft Division Safety Manual and HP-1.

2. APPLICABLE DOCUMENTS

- 2.1 The following publications of the issue in effect on the date of invitation for bid or request for proposal form a part of this specification to the extent specified herein.

2.1.1 C-55	Stripping Chromium Plate From Ferrous Alloys
2.1.2 FP-68	Application of Corrosion Preventive Compounds
2.1.3 IT-69	Nital Etch Inspection of High Strength Steel Parts

3. REQUIREMENTS

3.1 Materials and Equipment

- | | |
|---|--------------------------|
| 3.1.1 Cheesecloth | Commercial |
| 3.1.2 Aluminum Oxide,
1 to 5 microns | Commercial |
| 3.1.3 Wyandotte Nuvat | Wyandotte Chemical Corp. |
| 3.1.4 Sodium Hydroxide | Commercial |
| 3.1.5 Sodium Carbonate | Commercial |

3.2 Process Synopsis: Flow Chart - Processing of parts shall be as shown in Figure 1.

3.3 Processing Requirements

- 3.3.1 All parts that require anodic etch inspection shall be processed to the requirements of this specification by certified personnel.
- 3.3.2 Parts shall be rinsed free of all active chemicals immediately following each processing step with the exception of the solvent cleaning step.
- 3.3.3 After anodic etching, all chromium plated areas shall be inspected for evidence of grinding burns.
- 3.3.4 Parts that are stripped of chromium to evaluate the burning of the steel shall only be reprocessed once. If a part develops an anodic etch burn indication the second time, the part shall be submitted to Materials Review for disposition.

3.4 Anodic Etching Procedure

- 3.4.1 Solvent wipe or vapor degrease as necessary, to remove all oil and grease.

PROPOSED DRAFT

PROCESS SPECIFICATION: JT-70

NORTHROPNorthrop Corporation
Aircraft Division

DATE 1 July 1974

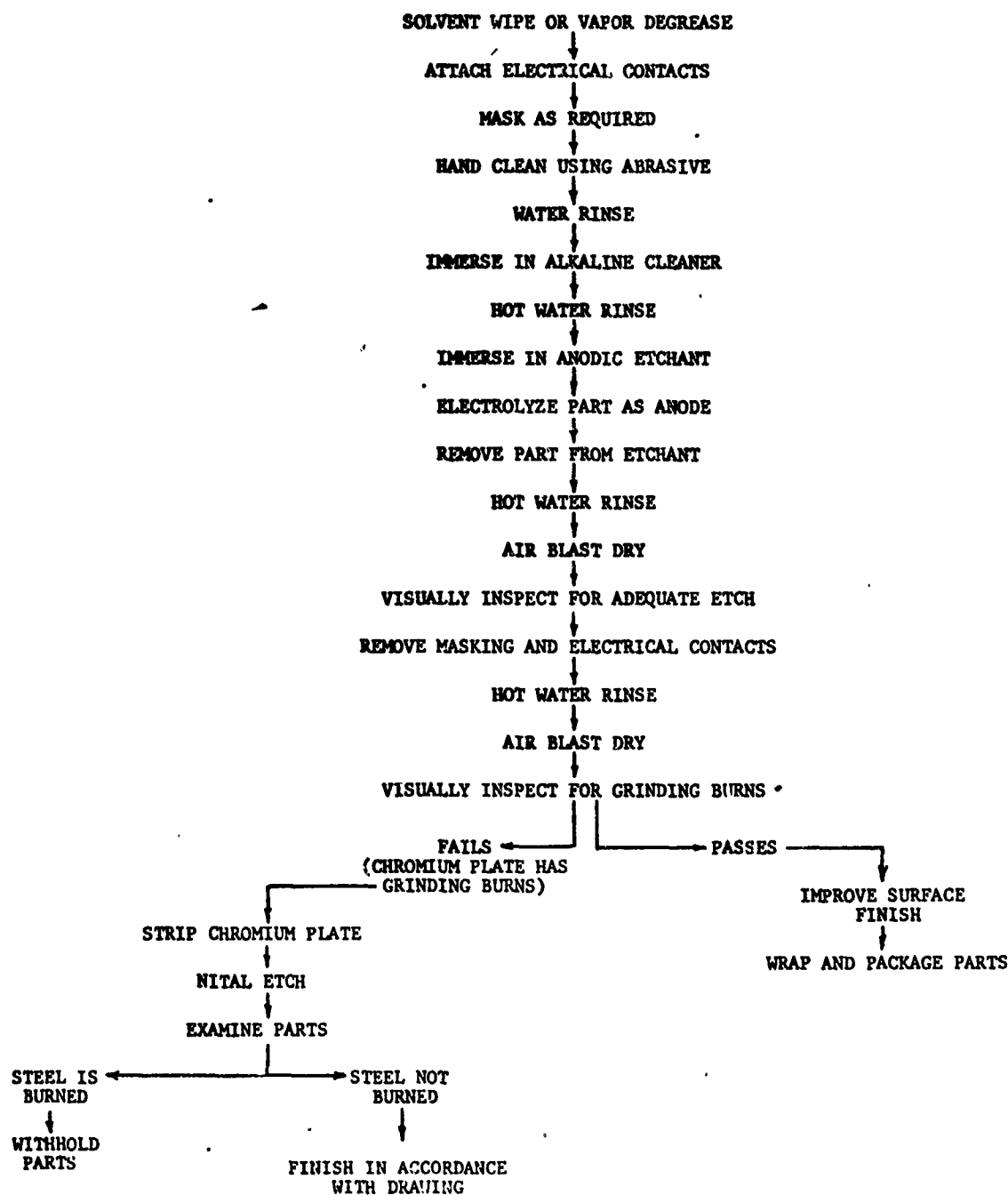


FIGURE 1. FLOW CHART

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- 3.4.2 Attach electrical contacts made from solid, stranded, or braided bare copper wire twisted around or clamped to nonchromium plated areas of the part. The presence of cadmium does not interfere.

CAUTION: Ensure that clips, clamps, or copper wire are tightly secured in a manner that prevents arcing. If arcing occurs, part shall be rejected and submitted to the Materials Review for disposition.

- 3.4.3 Mask all areas of part where there is no chromium plate including electrical contacts using masking tape, peelable maskant, and rubber stoppers, as applicable.
- 3.4.4 Hand clean part using clean cheesecloth and 1 to 5 micron aluminum oxide abrasive cleaner.
- 3.4.5 Water rinse to remove cleaner residue.
- 3.4.6 Immerse part for 1 to 5 minutes in alkaline cleaning solution (4.3.3).
- 3.4.7 Rinse in hot water 130 to 180 F to remove all cleaner residue.
- 3.4.8 Inspect chromium plate for a water-break-free surface, immediately prior to immersion in the etchant.

CAUTION: Clean chromium plated surfaces shall not be touched until etching and inspecting procedures have been completed.

- 3.4.9 Immerse chromium plated area of part in the anodic etching solution (4.3.4). The part shall not contact the sides or bottom of the container or other parts. Suspend the part by its electrical contacts from a support bridging the container.
- 3.4.10 Electrolyze part for 45 to 60 seconds at a current density of 2.5 to 3.5 amperes per square inch of exposed chromium plate using the part as the anode.
- 3.4.11 Remove part from etchant. Do not remove any masking materials.
- 3.4.12 Rinse in hot water 130 to 180 F.
- 3.4.13 Dry thoroughly with a blast of air.
- 3.4.14 Visually inspect part under a bright light for adequate etch. The surface condition of an adequately etched chromium plate should have a uniform matte or dull finish. Re-etch as required, but do not remove plating in excess so the dimensions are less than the minimum drawing requirements. A 45 second etch removes about 0.0003 inch on the diameter.
- 3.4.15 Remove masking materials and electrical contacts.
- 3.4.16 Rinse in hot water 130 to 180 F.
- 3.4.17 Dry with a blast of air.
- 3.4.18 Examine chromium plated areas visually under a bright light for evidence of grinding burns.
- 3.4.18.1 All parts showing evidence of grinding burns shall be stripped of chromium plate in accordance with C-55 and nital etched in accordance with IT-69.
- 3.4.18.2 All parts showing evidence of retempering or rehardening burns shall be withheld for Materials Review disposition.
- 3.4.18.3 All parts passing nital etch inspection shall be rechromium plated and finished to meet Engineering drawing requirements (including anodic etch).
- 3.4.19 Improve surface finish to meet Engineering drawing requirements.
- 3.4.20 Wrap and package parts for shipment.

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3.5 Acceptance and Rejection Criteria

- 3.5.1 Haze - Haze, a network of shallow surface cracks produced during normal chromium plating, is acceptable. The cracks do not extend entirely through the chromium plate. This type of cracking generally creates a hazy background appearance.
- 3.5.2 Mud Cracking - Parts that present an obvious crack network on the normal haze readily evident to the eye (may use up to 50X magnification) have mud cracking and are burned. The cracks extend through the chromium plate and are broader than normal cracked haze. These parts shall be stripped of chromium and nital etched to determine the degree of burning of the steel.
- 3.5.3 Spiraling - Parts with a clear grinding pattern of spiraling parallel lines or bands are burned.
- 3.5.4 Plunge - Abusive plunge areas resemble spiraling except that they do not traverse the part and may not be evident around the entire circumference of the part. These parts have a grinding burn.
- 3.5.5 Chatter - Parts with a dashed pattern of intermittent spiral lines or bands are burned. The pattern of chatter is perpendicular to the direction of wheel travel.
- 3.5.6 Grinding Checks - Parts with a clear sharp indication of a crack in the chromium plate have grinding checks and are burned.
- 3.5.7 Grinding Lines - The normal lines developed by good grinding must be distinguished from abusive grinding. Grinding lines are acceptable.

3.6 Facility Requirements

- 3.6.1 The equipment used for anodic etch inspection shall be in one local area.
- 3.6.2 A suitable area shall be available that contains a bright light over a large table to facilitate detail inspection of each part.
- 3.6.3 Tanks and equipment shall be clearly identified and have a suitable cover.
- 3.6.4 The anodic etching tank shall be fabricated from bare or polyethylene lined steel and shall have a 50 gallon minimum capacity. The tank shall be sized to permit complete immersion of the part without the part contacting the sides or bottom of the container or the other parts.

3.7 Qualification**3.7.1 Personnel Certification**

- 3.7.1.1 All Aircraft Division personnel performing anodic etch inspection in accordance with this specification shall be certified by Aircraft Division Quality Control Engineering.
- 3.7.1.2 All supplier personnel performing anodic etching in accordance with this specification shall be certified by either of the following procedures:
- Personnel shall be trained and certified by Aircraft Division Quality Control
 - Personnel shall be trained and certified by a program that is approved by Aircraft Division Quality Control.
- 3.7.2 Aircraft Division - The Aircraft Division facilities and procedures for processing parts in accordance with this specification shall be approved by Aircraft Division Quality Control Engineering.
- 3.7.3 Supplier Approval-Special Process - All suppliers processing parts in accordance with this specification shall be approved by Aircraft Division Quality Control and Materials Engineering. Alternate materials and procedures equivalent to those specified herein may be used by suppliers when submitted to and approved by the Aircraft Division.

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4. QUALITY ASSURANCE PROVISIONS**4.1 Responsibility for Inspection**

4.1.1 The processing supplier shall be responsible for the performance of all inspection requirements specified herein. The supplier shall use his own facilities to perform the inspection. The Aircraft Division reserves the right to perform the inspection set forth herein where such inspection is deemed necessary to assure that the processing conforms to the prescribed requirements.

4.1.2 Inspection records shall be kept complete and available to the Aircraft Division in accordance with the contract or purchase order requirements. These records shall contain all data necessary to determine compliance with the requirements of this specification.

4.2 Inspection - Quality Control shall assure that compliance with all requirements specified herein.

4.3 Process Controls

4.3.1 Solutions shall be periodically examined to ensure that the analysis and temperature of the solutions are maintained within the specified limits.

4.3.2 All tanks shall be covered when not in use.

4.3.3 Alkaline Cleaner Makeup and Control**4.3.3.1 Solution Makeup for Each 100 Gallons**

- a. For each 100 gallons of solution, fill the tank approximately 1/2 full of water.
- b. Slowly add 50 pounds of alkaline cleaner with gentle agitation.
- c. Mix thoroughly.
- d. Adjust the solution to operating level with water and mix thoroughly.

4.3.3.2 Control the solution within the following limits:

Wyandotte Nuvat	7 to 10 ounces/gallon
Temperature	130 to 180 F

4.3.4 Anodic Etchant Makeup and Control**4.3.4.1 Solution Makeup for Each 100 Gallons**

- a. For each 100 gallons of solution, fill the tank approximately 1/2 full of water.
- b. Slowly add 50 pounds of sodium hydroxide with gentle agitation.
- c. Add 100 pounds of sodium carbonate with gentle agitation.
- d. Mix thoroughly.
- e. Adjust the solution to operating level with water and mix thoroughly.

4.3.4.2 Control the solution within the following limits:

Sodium Hydroxide	5 to 10 ounces/gallon
Sodium Carbonate	9 to 20 ounces/gallon
Temperature	60 to 100 F
Voltage	12V D.C.

4.4 Qualification

4.4.1 Personnel Certification - Personnel to be certified shall be required to satisfactorily complete the following requirements.

- a. Take a training course at Aircraft Division or one approved by Aircraft Division covering the basic aspects of anodic etching.
- b. Pass an Aircraft Division written examination after completion of the course.
- c. Process test part(s) furnished by the Aircraft Division through their company anodic etching facility and satisfactorily interpret the results.

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4.4.2 Supplier Approval - Suppliers shall request from Aircraft Division that approval proceedings be initiated to approve their facility and certify their personnel for anodic etching in accordance with this specification. Approval of the supplier shall be based upon meeting the following requirements.

- a. Personnel pass the certification requirements in accordance with 4.4.1.
- b. Submittal of a copy of the supplier's shop procedure consisting of a full description of all materials and processes, written in a sequential how-to-do-it style, that will be used to meet the requirements of this specification.
- c. Presentation of a documented procedure that describes how the supplier intends to control the solution concentration and cleanliness.
- d. The facility shall meet the requirements of this specification.

5. PREPARATION FOR DELIVERY

5.1 Preservation and Packaging - All parts shall be preserved and wrapped or packaged to assure protection from corrosion and physical damage during handling, transportation, and storage. Parts shall be stored indoors in a dry area.

6. NOTES

- 6.1 Information pertaining to this specification may be obtained from Materials Engineering (3495/32), Aircraft Division.
- 6.2 Suppliers may obtain information pertaining to, or additional copies of, this specification from Northrop Corporation, Aircraft Division, Procurement Department (6000/71), 2031 E. Mariposa Ave., El Segundo, California 90245.

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